Nutrient Tracking Tool (NTT)
User Manual

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Nutrient Tracking Tool (NTT) Overview

The **Nutrient Tracking Tool (NTT)** was designed and developed by the Texas Institute for Applied Environmental Research (TIAER), Tarleton State University with funding from USDA Office of Environmental Markets, USDA-NRCS Conservation Innovation Grants program, and various state agencies.

NTT is a web-based, site-specific application that estimates nutrient and sediment losses at the field scale or at the small watershed scale.

Agricultural producers and land managers can define a number of management scenarios and generate a report showing the expected nutrient loss differences between any selected scenarios for a given field or small watershed.

NTT compares agricultural management systems to calculate a change in expected flow, nitrogen, phosphorus, sediment losses, and crop yield. Estimates are made using the **APEX** model (Williams et al. 2000). Results represent average losses from the field based on 35 years of simulated weather.

NTT requires regional soils, climate and site-specific crop management information. NTT currently provides selections for all regions of **U.S. and Puerto Rico territory**, but it has only been validated for a limited number of states and counties. As validation becomes possible in other parts of the country, parameter files may be updated for additional counties in future versions.

There are two versions of new NTT program available:

- The BASIC version is a user-friendly version of NTT that allows users to estimate N, P and sediment from crop and pasture lands.

- The Research and Education version of NTT (NTT-RE) was developed for researchers and educational institutes for teaching and training purposes. NTT-RE includes additional functions allowing the user to view and edit soil layers, view crop water and nutrient stresses, and modify and the APEX parameters file for calibration and validation purposes.

- The data sources and APEX simulations in both versions are identical. For more information regarding NTT, please refer to Saleh et al. (2011 and 2015).

About APEX

NTT uses a biophysical simulation model, the Agricultural Policy Environmental eXtender model (APEX), version 0806, to process user supplied information (APEX; Williams et al., 2000). Below are characteristics of the APEX model.

- The <u>APEX (Agricultural Policy/Environmental eXtender)</u> model was developed to extend the **EPIC** model capabilities to whole farms and small watersheds (Williams et al., 2000). □ The individual field simulation components of EPIC were used for APEX development.
- In addition to the EPIC functions, APEX has components for **routing water, sediment, nutrients,** and **pesticides** across complex landscapes and channel systems to the watershed outlet.
- Recently, the **carbon fate** and **transport** function of **CENTURY** model was incorporated in the latest version of APEX (version 2110). This allows APEX to simulate carbon dynamics in soil-plant system.
- APEX also has **groundwater** and **reservoir** components. A field or watershed can be subdivided as much as necessary to assure that each subarea is relatively homogeneous in terms of soil, land use, management, etc.
- The **routing mechanisms** provide for evaluation of interactions between subareas involving **surface runoff, return flow, sediment deposition** and **degradation, nutrient transport,** and **groundwater flow.**
- Water quality in terms of **nitrogen** (ammonium, nitrate, and organic), **phosphorus** (soluble and adsorbed/mineral and organic), and **pesticides concentrations** may be estimated for each subarea and at the watershed outlet.
- Commercial or manure may be applied at any rate and depth on specified dates or automatically.

Disclaimer

Although NTT has been tested by its developers, NO warranty, expressed or implied, is made as to the validity of the results and functioning of the program and related program material, nor shall the fact of distribution constitute any such warranty, and NO responsibility is assumed by the developers in connection therewith. The user assumes all risks and responsibilities for the use and application of NTT and interpretation of the results generated from the tool.

The authors and their affiliated institution, TIAER, and any other U.S. Government agencies will NOT be liable to NTT users for any damage, including lost profits, lost savings, lost time, actions by regulatory agencies, or any other direct or indirect incidental or consequential damages occurring from the use of or inability to use NTT, its databases, its results, or its documentation for any purpose.

References

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System Requirements

Minimal Requirements

1. **Windows:** X86 or X64 1.6 GHz or higher processor with 512-MB of RAM
2. **Macintosh (Intel-based):** Intel Core Duo 1.86 GHz or higher processor with 512 MB of RAM

Supported Web Browsers

The Nutrient Tracking Tool **(NTT)** has been tested on the following browsers:

Apple Macintosh OS 10.5.7+ (Intel-based):

1. Firefox 12+
2. Safari 4+
3. Chrome 12+

Microsoft Windows 8.1 Desktop:

1. internet Explorer 11
2. Firefox 12+
3. Chrome 12+

Microsoft Windows 8 Desktop:

1. Internet Explorer 10
2. Firefox 12+
3. Chrome 12+

Microsoft Windows 7:

1. Internet Explorer 8 and 9
2. Firefox 12+
3. Chrome 12+

Microsoft Windows 7 SP1:

1. Internet Explorer 8, 9, 10, and 11
2. Firefox 12+
3. Chrome 12+

2012r2

1. internet Explorer 11

2. Firefox 12+
3. Chrome 12+

Microsoft Windows Server 2012:

1. Internet Explorer 10
2. Firefox 12+
3. Chrome 12+

Microsoft Windows Server 2008 SP2:

1. Internet Explorer 7, 8, and 9
2. Firefox 12+
3. Chrome 12+

Microsoft Windows Server 2008 R2 SP1:

1. Internet Explorer 8, 9, and 11
2. Firefox 12+
3. Chrome 12+

Microsoft Windows Vista:

1. Internet Explorer 7, 8, and 9
2. Netscape 9.0
3. Firefox 12+
4. Chrome 12+

Microsoft Windows Server 2003/Windows XP:

1. Internet Explorer 7 and 8
2. Netscape 9.0
3. Firefox 12+
4. Chrome 12+

Display Resolution

The software has been tested and works correctly at resolutions as low as 800 × 600, but the lower the resolution, the more you will have to scroll.

JavaScript

To run **NTT**, JavaScript is required. If JavaScript is disabled in your browser, the application simply will not work at all. You will see an error message in this case.

Popup Blocker

By default, **NTT** opens some content in an external browser window, specifically:

- Links to other sites

- **Help** Screens

If you have a pop-up blocker configured, it will probably not allow this. If you wish to open these types of content in an external browser window, configure your pop-up blocker to allow pop-ups from this site.

Navigation Basics

The Nutrient Tracking Tool was designed to be user friendly, with nine main pages:

On the **Projects** page, users can create a project by enter the name and description of the project, open saved projects, or upload projects from local source.

On the **Location** page, the users delineate the field or fields in their project using the interactive map. Alternately, users may upload their own shape files.

On the **Fields** page, the users either create new fields or verify the fields drawn on the Location page. Clicking on the fields allows the user to further define the field characteristics in the soils and management pages.

On the **Soils** page, the users may verify or delete the soils returned by the SSURGO database for their field. Users are also asked to indicate the soil P content for the field.

On the **Management** page, users create and name one or more management scenarios for the field. Each management scenario must be further defined on the Operations and Conservation Practices sub-project pages. Once the management scenario(s) has been defined, users may also simulate the scenarios by selecting the box next to the scenario name and clicking "simulate selected scenario".

On the **Operation** page, users create the crop schedule and define management for the given field management scenario.

On the **Conservation Practices** page, users indicate the conservation practices that are in place on the field for the given field management scenario.

On the **Results** page, users can view and compare results of up to three management scenarios for a given field in tabular or graphical presentations. In addition, a PDF-formatted report for the project and results summary will be available for upload.

On the **Field Routing** page, users are able to create and name field routing scenarios. This also can be used for simulating for different scenario management in multiple fields or at subbasins within a watershed. A routing scenario will route runoff, sediment, and nutrients from one field to the next (within a subbasin and from one subbasin to the next if used for a watershed) in the specified order. For each routing scenario users will need to list the fieldscenario order.

To advance to the next page, simply click **Save and Continue.**

Projects Page

After creating an account in NTT and logging in, you will be directed to the My Projects page. My Projects displays all projects that the user has previously created. On this page, users can create a new project, open a saved project, or upload a project stored on their local machine.

Create a New Project

Click the **Create New Project** button to create a new project. You will be asked for the project name and a project description (optional).

After you have entered the information, click the Save button to save the information and continue.
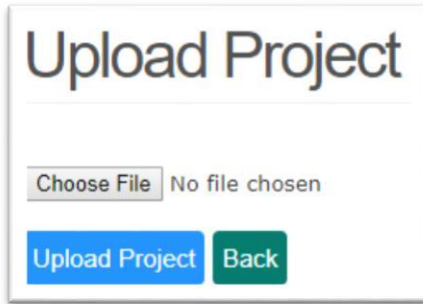

Upload Project

Users may use the **Upload Project** button to retrieve an NTT Save File containing previously saved information and stored on their local machine.

Click **Upload Project**, then select **Choose File** and navigate to the saved file on your computer. After you have selected the project, click the **Upload Project** button to upload the project and continue.

Open Saved Project

To open a saved project, simply click on the project name to open the project and begin editing.

Location Page

After creating a new project, users will be asked to define the location of the project using the interactive Google map. The interactive map allows the user to define one or more areas of interest (AOI). The area of interest should correlate to fields within the project area. The map is **ONLY used for mainland United States**. If you would like to simulate using an area outside of mainland United States, follow the instructions for User Input.

When defining the AOI, the underlying weather, soils, and slope information is retrieved from the underlying spatial data.

Mapping System

There are two ways to define your areas of interest: you may manually draw your areas of interest using the zoom features and drawing tools on the interactive map, or you may upload your own shapefle.

Upload Shapefile

If you already have a shapefile that you would like to use as your project area you may upload the shapefile. You will need to upload a file that consists of at least four files with the same name but different extensions (.shp, .shx, .dbf, and .prj). Ensure that the .shp file is the format of an ESRI Shapefile that uses the geographic coordinate system (latitude and longitude). The shapefiles need to be within a .zip folder, and you need to upload that .zip folder.

1. **Choosing a Shapefile:** To choose a shapefile, select the button Choose file under the Upload Shapefile as shown in the figure:

2. **Uploading a Shapefile:** Once you have located the .zip file containing the shapefiles you wish to use, upload the files by clicking the Upload Shapefile button.

3. **Submitting a Shapefile:** You need to submit the changes to the map once you have uploaded. Be sure to click the Submit button.

Zoom and draw the AOI

If you do not already have a shapefile you may draw your AOI using the zoom features and drawing tools on the interactive map. Users may draw multiple AOIs. AOIs should represent fields within the project area.

1. **Zoom to your area of interest:** There are several ways to zoom in to your area of interest. You may enter an address, enter the lat/long (using the correct format where latitude comes before longitude, north latitude is positive, east longitude is positive), select the state and county from the available pick lists, or manually zoom on the map using the zoom tool.


2. **Draw your Area of Interest (AOI):** Once you are zoomed in on your area of interest, click the polygon button at the top center of the map. Next, use your mouse to click the corners of your polygon as shown in the figure below. A field is considered an area of interest in NTT. After drawing the field, a message will pop up telling the user to enter the name of the AOI as shown below. Enter the name of the field and click OK. As the user enters the name, it will replace the default name in the text box for the field as shown in the following figure. From this point the field name entered will refer to the selected location. You may create multiple AOIs/fields for your project. Simply click on the polygon button again and create additional AOIs.
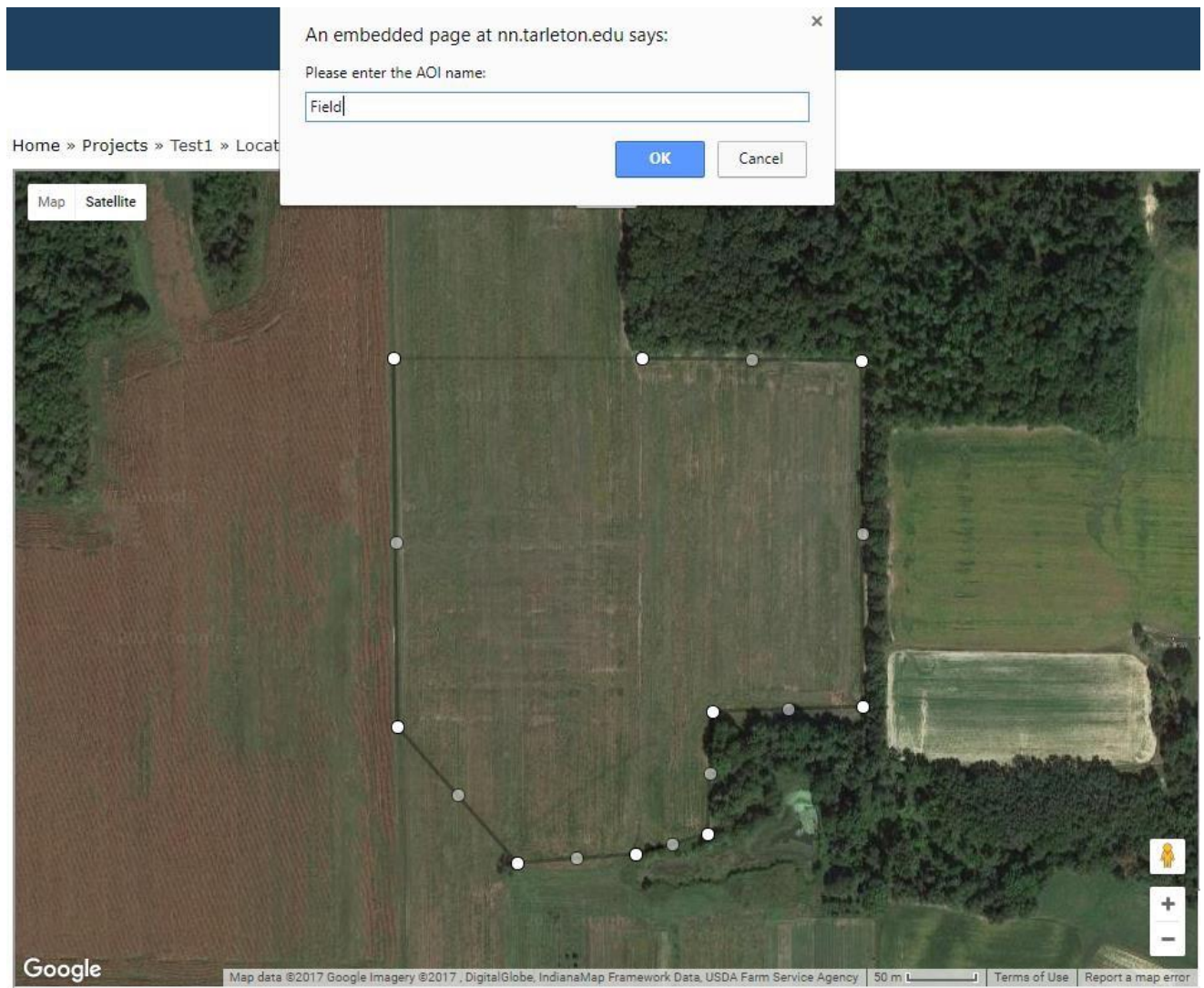
Once the user clicks **OK**, the field location will be highlighted as shown below.
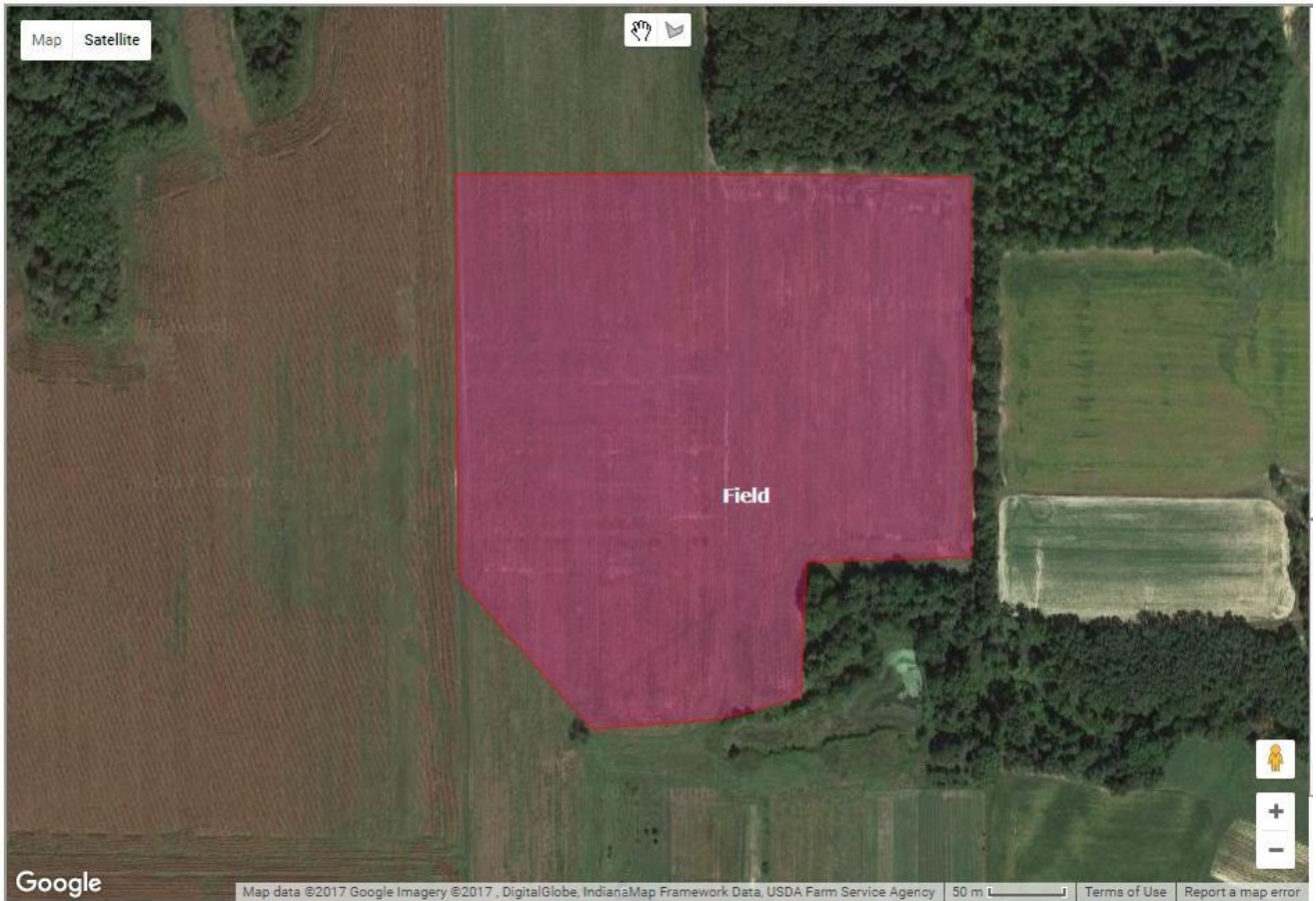
3. **Submitting AOIs:** Once you have one or more AOIs, you MUST to click the Submit button. The actual map is a different program that is being run within NTT. By clicking Submit, the drawings are actually submitted to NTT.

4. **Deleting AOIs:** To remove an AOI, first select the field that you would like to delete, and then click the Remove AOI button.

Fields Page

The Fields page displays the AOIs/fields that you have defied for your project. From the Fields page, you can begin entering scenario and management information for each field. You may also delete fields/AOIs from your project on this page.

If you selected Mapping System, the fields that you drew or uploaded will already be on the Fields page. This page will simply allow users to verify the field(s) and advance.

Deleting a Field

To delete field(s), simply click the ✖ icon on the actions column.

Define Field Management

To begin defining management scenarios for your field, click on the hyperlinked field name. You will advance to the field-level **Soils** page for your field where you will begin defining field characteristics and management scenarios. The Soils page is also where you will be able to change the field/AOI name as well as revise the field/AOI area. **(See Soils page for more information.)**

Add Fields/AOIs

To add more fields or AOIs to your project you must navigate back to the Location page using the left-hand menu. From the location page you can draw and submit additional AOIs that will then appear on the Fields page.

Changing Field Name and Area

The field name and area can be changed on the Soils page. Simply click on the hyperlinked field name which will take you to the field-level Soils page. At the top of the page you may change the field name and modify the field area if you desire. **(See Soils page for more information.)**

Soils Page

After clicking on a field to begin editing on the **Fields** page, the user will be directed to the **Soils** page. The Soils page is a field-level page. The Soils page allows the user to rename the field and adjust the acres; input soil P values; and verify soils returned from the SSURGO soils database for the particular field selected in the Fields page (Just for E version). NTT returns a maximum of 3 soils for every field. These soils represent the most predominant soils in the AOI. NTT is limited to 3 soils in order to minimize model processing time.

Field Name/Area

Field Name: The name that the user has given to the AOI is pre-filled here. The user may modify the name if they wish. The new name will be updated on the Fields page as well.
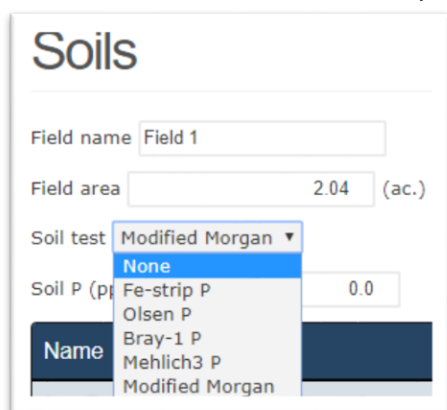
Field Area: Field area displays the calculated area of the field in acres. The user may refine this value if needed.

Soil Phosphorus

Soil P test values provide NTT with a starting point for phosphorus in the soil. If you do not have a soil P test for your soil, leave these fields blank and NTT will use default soil P values.

Soil P Test: The user should select a soil test, if applicable, that was used to determine the soil phosphorus. Currently NTT includes conversions for the Fe-strip test, Olsen, Bray-1, and Mehlich-3 tests. If you have used a different test, please select Other. If you do not have a soil test for phosphorus, please select None. As we modify NTT for other parts of the country we will include additional tests and P conversions.

Soil P: Users should enter the soil phosphorus test value for their field, if available. If None was selected for the P test then this field will be disabled and a minimum phosphorus concentration in the soil will be used. Similarly, if a soil test is selected, but the field Soil P value is left blank, the tool will assume a minimum phosphorus concentration in the soil.

Soil test phosphorus (STP), obtained by the following methods are converted to Mehlich-3 (M3) before inputted in soil data database (The STP-depth is set at 0-6-inch depth by default). The user STP input in NTT is converted Mehlich-3 equivalent using the following equations:

1. Modified Morgan (MM) method (Winchell et al., 2011)

   M3 = 6.718 × MM − 11.83 × PH − 32.757 × MM/AL + 90.73

   Where, PH soil PH and AL is soil Aluminum at the top soil 6-inch depth.

2. Fe_strip method (Peter et al., 2007) M3=

   0.10 + 1.61 Fe-strip P

3. Olsen_P method (Peter et al., 2007) M3 =

   14.8 + 1.54 Olsen P

4. Modified Bray-1) method (Peter et al., 2007)

   M3 = 10.8 + 0.99 Bray-1 P

Manage/Modify Organic Matter

Between 1 and 3 soils will appear in the list of soils returned for your field. These represent the most predominant soils in your field as returned by the SSURGO Soils database.

NTT will return the **soil name** and the **soil group** for each soil. These data are derived from the SSURGO soils database.

The soil **slope** for each soil is calculated dynamically by NTT using the 30 meter Digital Elevation Model (DEM) layers associated with your field.

The default **soil organic matter (%)** value returned by the SSURGO soils database is displayed for each soil in the soils list. However, if the user has more precise data they may enter it here.

Percentage represents the adjusted coverage area of the soil for your field. Because NTT selects only the 3 most predominant soils, the coverage area of each is proportionally expanded to equal 100% coverage of the field.

Name	Group	Slope	Organic Matter (%)	Percentage
Agra-Foraker complex, 3 to 5 percent slopes	D	2.804	2.0	95.88
Shilder-Westsum complex, 5 to 20 percent slopes	C	2.051	2.0	4.12

Save and Continue

Management Scenarios

Overview

Once clicking Save and Continue on the Soils page, users will be advanced to the **Management Scenarios** page. The Management Scenarios page is a field-level page where the user creates, manages and simulates management scenarios for each field. Users may create multiple scenarios for each field in order to compare how different crop management and conservation practices will impact nutrient losses and yields.

Creating a Field Scenario

The user can create a scenario by clicking on the **Add New Scenario** button. Users will be asked to name the scenario, for example "Baseline" or "Alternative" or "Auto-Irrigation". After giving a name to the scenario, click the **Save** button which will create the scenario and advances the user to the **Operations** page where the user will begin to define the crop schedule and conservation practices. (See Operations Page.)

Copy Scenario from other Field

The user can copy scenarios from other fields and use it in the existing field. To copy scenarios click **Copy Scenario from other Field** at the top of the page, then select the field and scenario that you wish to copy. Click the **Copy** button when done. The scenario will be copied and will appear in the list of management scenarios for that field. In Addition, a scenario could be duplicated and renamed and modified for different management scenario within a field by using the copy key under the action options.

Manage Field Scenarios

The Management Scenarios page includes a list of the scenarios created for the field. The list includes the scenario name, fields for weather, soils and operations, simulation date, and an actions column.

A green check will appear in the weather, soils, layers and operations columns where these are present for the scenario. In order to successfully simulate a scenario, all four of these elements

must contain a green check. The **weather, soils** and layers should be checked when a management scenario is first created, as these elements are derived from the map and are automatically associated with each field. However, the operations column will be blank until the user enters management information for the scenario. A green check will appear in the **operations** column once management information is present for the field.

The **simulation date** field indicates the date on which the scenario was last simulated by the model. If the simulation date field is blank it means that the field has not been simulated. (See Simulating Scenarios to learn more about how to simulate a scenario.)

The **Actions** column contains three different icons, representing different actions. The edit ✏ icon allows you to modify the name of the scenario. The copy 📄 icon creates a copy of your management scenario. And the delete ✖ icon will delete the management scenario.

Simulating Field Scenarios

Once you have completed one or more scenarios for your field you must simulate the scenarios to obtain results. By simulating the scenarios you are running the project through the APEX model which will return results for estimated nutrient and sediment losses as well as crop yields. To simulate a scenario, check the box next to the scenario or scenarios you wish to run and then click the **Simulate Selected Scenario** button.

Before attempting to simulate a scenario, please make sure that there are green check marks in the weather, soils, layers and operations columns are present. Each of these elements must be present in the scenario before it can be successfully simulated by the APEX model. Simulation of the scenarios may take one or more minutes.

Once a scenario has been successfully simulated the **simulation date** field will show the date and time of the most recent simulation.

Note: If you modify a management scenario you will need to re-run the scenario in order to view results of the updated scenario.

Management Scenarios						

Add New Scenario | Copy Scenario from other field

Simulate Selected Scenario | View Results | Download APEX Files

To select a scenario click on the scenario name, to simulate scenarios click on the check box

☐ Name	Weather	Soils	Layers	Operations	Simulation date	Actions
☐ baseline	✓	✓	✓	✓	2017-11-30 18:23:39 UTC	✏ 📄 ✖
☐ alternate	✓	✓	✓	✓	2017-11-30 18:23:50 UTC	✏ 📄 ✖
☐ alternate buffer	✓	✓	✓	✓	2017-11-30 18:24:02 UTC	✏ 📄 ✖

Viewing Results

Click the **View Results** button to view results of the simulated scenarios. You will be advanced to the results page where you may select up to three scenarios to compare at a time. (See Viewing Results for more details.)

Downloading APEX files

After you have simulated a management scenario you can download the APEX files if you wish. This feature is generally for advanced users who may wish to save these files to run in another version of APEX. Alternately, this feature can be used for those who wish to store project files locally rather than on the server. APEX files can be uploaded and viewed on the Project Management page. To download the APEX files, select a management scenario and then click **Download APEX Files.**

Operations Page

Once a scenario has been created on the **Management** page, the user is advanced to the **Operations** page to begin inputting the management characteristics such as the crop schedule, tillage, fertilizer, harvest, and grazing operations.

A cropping system is **REQUIRED** for the user to be able to advance and simulate the results. The user can add rotations that are one year in length or much longer. A field may have multiple crops, or a single crop. There are different options available in **Operation Page** for manipulating a cropping system as below:

Add Crop to Rotation

To add a crop to the rotation, click **Add Crop to Rotation.** The user is then asked to select a crop from the pick list, a tillage type (No-till, reduced till, or intensive till), and rotation year. The crop list is customized according to the region in which the project is located. The rotation year indicates the sequence of the crop within the crop schedule, it does not represent the calendar year. Once the user has selected a crop type, tillage type and rotation year, clicking **Upload** will add the crop to the crop schedule.

Once a crop is added to the crop schedule you will note that it includes several default management characteristics including a planting date, fertilizer applications, tillage schedule, and harvest. These operations can be modified or deleted as needed and new operations can be added.

The operations list for each crop can be rolled up or expanded by clicking the [-] or [+] buttons next to the crop name respectively.

Add New Operation

Users can add operations to their rotations or build a cropping system from scratch using the **Add New Operation** button at the top of the page. You will be asked to select the crop, operation type, year, and date. The year indicates the position of the crop in the crop schedule, for example, CORN year 1 and SOYBEAN year 2.

Depending on the operation type there will be additional fields to enter. Below are descriptions of the different operation types and the additional required fields for each.

Planting

- Plant method: User must indicate the planting method using the pick-list of planting equipment provided.

- Seeding Amount (seeds/sq. ft.): This field is pre-filled with standard seeding rates for each crop type. If the user has more specific information on seeding rate they may enter it here.

Fertilizer

- Fertilizer category: User must indicate the fertilizer category (commercial, liquid manure, or solid manure).

- Fertilizer Type: The fertilizer type pick list will vary depending on the fertilizer category selected. For manure fertilizer, pick list will contain types of animal manure.

- Amount: User needs to indicate the amount of fertilizer applied. Units will vary depending on the type of fertilizer selected (lbs/ac, tons/ac, 1000 gals/ac).

- Depth: If the fertilizer is incorporated, user should indicate the depth of incorporation here. If fertilizer is not incorporated, this field can be left blank.

- Fertilizer Composition (commercial fertilizer only): For commercial fertilizer, these fields indicate the N and P composition. These fields are pre-filled based on the fertilizer type selected, but can be modified if needed.

- Total N concentration (solid/liquid manure only): For manure fertilizer, the user should indicate the total N content per ton of solid manure or per 1000 gallons of liquid manure. Typical values are pre-filled for the user, but can be modified.

- Total P concentration (solid/liquid manure only): For manure fertilizer, the user should indicate the total P content per ton of solid manure or per 1000 gallons of liquid manure. Typical values are pre-filled for the user, but can be modified.

- Moisture content (solid/liquid manure only): For manure fertilizer, this is the percentage, by weight, of moisture content in the manure. Typical values for each manure type are provided, but can be modified by the user.

Tillage

User must indicate the tillage method using the drop down selection.

Harvest

No additional data needed beyond the crop, year and date.

End of Season

End of Season requires only the crop, year and date information from the user.

Note: End of season indicates to the model that the crop is removed from the field. If an End of Season operation is not present, then the model assumes that the crop is left growing. End of season should be used for all annual crops. For certain perennial crops like hay and pasture, End of Season operations may be absent from the crop schedule.

Manual Irrigation

- Irrigation method: The user indicates the type of sprinkler system that is being used.

- Amount: User indicates the volume of water applied in this irrigation event in inches.

- Irrigation efficiency: This field defaults to a typical irrigation efficiency value (as a fraction) based on the irrigation method that is selected. This value can be modified.

Note: On the Conservation Practices pages there is an option for **autoirrigation** and **autofertigation** which automates irrigation on your field based on user parameters. Please see **autoirrigation/autofertigation** for more information.

Continuous Grazing

- Start/End Grazing dates: User indicates the start and end dates of grazing on the field.

- Animal Type: User indicates the type of animals being grazed on the field.

- Animal Units: User indicates the total animal units being grazed on the field. Animal units represent 1,000 lbs of live animal weight.

- Hours in Field: User indicates the total hours per day that animals are grazed in the field.

Rotational Grazing
The rotational grazing operation, unlike continuous grazing, assumes that the pasture is divided into paddocks and that livestock are moved through the paddocks as needed. Thus, each paddock is given a recovery period between grazing events, improving vegetative cover.

- Start/End Grazing dates: User indicates the start and end dates of grazing on the field.

- Animal Type: User indicates the type of animals being grazed on the field

- Animal Units: User indicates the total animal units being grazed on the field. Animal units represent 1,000 lbs of live weight.

- Hours in Field: User indicates the total hours per day that animals are grazed in the field.

- Number of consecutive days grazed at a time (in each paddock): User indicates the number of days livestock will spend in each paddock before being rotated to a new paddock.

- Pasture rest time (days) between grazing: User indicates the number of days that the pasture is rested between rotational grazing cycles.

Burn
No additional data required by users beyond crop, year and date

Liming

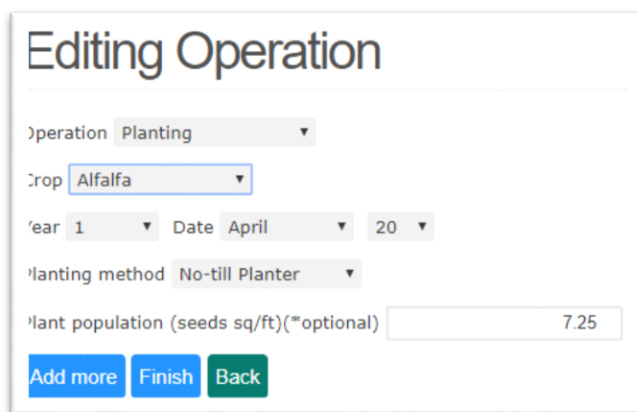Amount: User must indicate amount of lime applied (lbs/ac).

Add a Cover Crop

To add a cover crop, click **Add Cover Crop** button at the top of the page. Users will indicate the type of cover crop, cover crop year, planting date, and planting method. The cover crop year should indicate the year within the rotation that the cover crop is planted. NTT will

automatically add the harvest date for the cover crop based on the next crop in the rotation. Cover crops are not fertilized and are not harvested, rather they are chopped prior to planting of the next crop in the rotation.

Note: If you wish to add a commercial cover crop, please do so as you would add another crop to your crop schedule. For example, add "Winter Wheat" to your crop schedule by clicking **Add Crop to Rotation** and selecting from the crop pick-list (NOT using the Add Cover Crop button). Adding a crop this way will allow users to apply fertilizer, tillage and harvest operations (etc.).

Edit Operation

Users may change the values or any other information in an operation by clicking on the **Edit** icon in the **Actions** column next to the operation. Once the operation has been edited, click **Finish** to save and return to the Operations page. Clicking **Back** will return the user to the Operations page without saving changes to the operation. Clicking **Add More** will save change to the current operation and allow the user to continue adding additional operations without returning to the Operations page.

Delete an Operation

To delete an operation, click the Delete ✖ icon in the Actions column of the operation you wish to delete.

Switch View

By clicking Switch View at the top of the page, you can switch your view from one that is organized by crop and operation type to one that is organized by date. Once you are satisfied with your crop schedule, click Continue at the top of the page. You will be advanced to the Conservation Practices page where you can indicate any conservation practices that are present on the field.

Conservation Practices

Once the crop schedule and operations have been added, click the **Continue** button at the top of the Operations page. This will advance to the **Conservation Practices** page. On this page users will indicate the structural conservation practices that are in place on the field. If no conservation practices are in place on the field, simply click **Save and Continue** at the bottom of the Conservation Practices page which will return the user to the Management Scenario page. Alternately, users may navigate directly to the Management Scenario page using the left hand navigation links.

Add a Conservation Practice

To add a conservation practice, click the check box in the Select column of the conservation practice you wish to add. Users may add more than one conservation practice to a field, though some conservation practices are mutually exclusive. (See Mutually Exclusive Conservation Practices for more details.) The conservation practices are organized by groups, and the user may select the specific practice they are interested in adding. To add the conservation practice, expand the particular group by clicking the check box in the select column. Once the conservation practice group is selected, select the specific option within the group that you wish to add and fill in any required fields.

Mutually Exclusive Conservation Practices

To add a field/scenario or subproject to run, select either **Add Subproject to Run** or **Add Field/Scenario to Run**. The particular button that will be available will depend on the selection

that you made under the heading **Select Type**. Once you have added all of the fields/scenarios or subprojects, it is time to simulate. The fields/scenarios or subprojects that you added will be seen on the page, as shown below:

1. Autoirrigation and Autofertigation

2. Grass Buffer and Forest Buffer

3. Grassed Waterways and Grass/Forest Buffers 4. Contour Buffer and Grass/Forest Buffers

Conservation Practice Descriptions

Below are the descriptions of the conservation practices that are available in NTT.

Autoirrigation and Autofertigation

Autoirrigation refers to Automatic irrigation systems are irrigation systems that are controlled by a computerized controller. Autoirrigation overall can greatly increase crop yield. Within NTT, the autoirrigation feature will irrigate the field when certain user-supplied criteria for water stress and frequency are met, and will limit water application to the user supplied maximum application amount. User inputs required for auto irrigation include:

1. **Irrigation Type:** Irrigation types include sprinkler, furrow/flood, drip, and furrow diking.

2. **Irrigation Efficiency:** This value is the fraction of irrigation application that is not lost to runoff. This must be a value that is greater than 0 and less than or equal to 1. The closer the value is to 0, the greater the percentage of water lost to runoff and does not reach the crop. A value of 1 means that no water was lost to runoff. Different irrigation systems have different irrigation efficiencies. NTT supplies typical irrigation efficiency values for the irrigation type selected, but these values can be modified by the user.

3. **Irrigate a Maximum of every (0-365) days:** This field is asking for the maximum frequency (in days) that irrigation can take place. If the frequency is set to 1, then irrigation can occur every day. If frequency is set to 7 then irrigation can occur, at most, once a week. The value can be any whole number greater than or equal to zero and less than or equal to 365.

4. **Plant Water Stress Factor:** The water stress factor indicates the water stress level of the crop. This is the value that is used to trigger the start of auto irrigation. For example, if water stress is set to 0.8 then NTT will trigger an irrigation event when the crop is 80% water-stressed, as long as conditions for maximum frequency are also met. The plant water stress factor can be any value greater than 0 and less than or equal to 1. The closer the value is to 100, the less water stress is allowed before the automatic irrigation is turned on.

5. **Maximum Single Application:** This value signifies the maximum amount of water than can be applied in a single irrigation event. It is in inches, and it can be any number greater than 0. If there are no constraints on the maximum single application, this value should be set to a high number.

Autofertigation is the application of fertilizers, soil amendments, or other water-soluble products through an autoirrigation system. Autofertigation is an automatic fertilization process in which fertilizer is dissolved and distributed through the irrigation system. This makes autofertigation very similar to autoirrigation with the only additional user input required being nitrogen concentration.

6. **Nitrogen Concentration:** The amount of nitrogen in irrigation water in parts per million. Total N applied through autofertigation will be dependent upon the overall irrigation frequency which in turn is dependent upon water stress, frequency and maximum application factors set by the user.

Note: Nutrients applied through autofertigation are in addition to the nutrients from commercial and manure fertilizers that are applied to the crop (as part of the fertilizer operations). If you spray-irrigate manure on your field periodically it is best to represent this as a manure application and not through the autofertigation feature.

Tile Drain

Tile drainage is a practice for removing excess subsurface water from agricultural soils using perforated pipes. Drainage brings excessive soil moisture levels down for optimal crop growth. Tile drainage is often the best recourse for reducing high subsurface water levels to improve crop yields. Too much subsurface water can be counterproductive to agriculture by preventing root development, and inhibiting the growth of crops. Excessive water also can limit access to the land, particularly by farm machinery.

For NTT applications, underground drainage systems are simulated in APEX. The depth of the drainage system to reduce plant stress is a key parameter used in simulating tile drainage systems in NTT. Tile drainage simulation in NTT increases subsurface flow, which may provide an avenue for increased nutrient losses in subsurface flow. The only input for tile drains is depth.

Depth: This is the depth in feet at which the drainage system is installed. It is any number greater than 0.

Wetlands

Wetlands are those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support,

a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas.

The wetland area is simulated as a shallow reservoir (1 ft. depth) with growing wetland vegetation – it is essentially simulated as an artificial wetland and not a natural wetland. The slope of wetland area is set as 1%. Simulated wetlands trap sediment, reduce runoff, increase infiltration, and also increase uptake of water and nutrients by the vegetation in the area covered by the wetland. Inputs required for wetlands include:

1. **Area:** The area of the wetland is input in acres. Since this area is no longer able to be used for crop production, there may be a lower total crop yield (although there may be a greater crop yield/acre).

2. **Is wetland area included in your AOI?:** Users indicate here whether the AOI representing the field includes the wetland feature within the drawn polygon or if the wetland feature lies outside of the AOI. If the wetland feature is included in the AOI, then the wetland acres will be subtracted from the field area.

Ponds/Water and Sediment Control Basins

Water and sediment control basins (WASCOBs), or ponds, consist of an embankment across the slope of a field or minor waterway to temporarily detain and release water through a piped outlet or through infiltration. They are constructed perpendicular to the flow direction and parallel to each other. WASCOBs are usually installed in areas where the land is relatively steep and undulating. They detain water from contributing areas, inducing sedimentation and controlling the release of water, thereby reducing the erosive power of the water downstream. Additional benefits are settling of sediment-bound pollutants and some infiltration. Only one input is required for ponds: fraction of area controlled by ponds.

Fraction of Area Controlled by Ponds/WASCB: This is the fraction (a value between 0 and 1) of the field runoff that flows through (is controlled by) the pond/WASCOB. As modeled, ponds only treat runoff that originates in this field. Inflow from other fields is not routed through the ponds. Ponds/WASCOBs are assumed to be within field.

Grass Buffer/Forest Buffer

Forest buffers are linear wooded areas with well-developed root systems, an organic surface layer, and understory vegetation. When they are adjacent to open water they are referred to as riparian forest buffers. Non-riparian buffers are linear wooded areas along down-slope field edges. Forest buffers trap sediment and increase infiltration, thereby reducing sediment and nutrient losses. Forest buffers often include a grass buffer between the field and the forested buffer. If present, please also include the width of the grass buffer.

The inputs for Forest Buffer are the following:

1. **Area (ac.):** This is the total area of the Riparian Buffer. This field is optional. If left blank, the area will automatically be calculated using the width of the buffer and the length of the field edge (where the field edge is calculated as the square root of the area of the field).

2. **Grass Strip Width (ft.):** This is the width of the grass strip between the crop and the forested buffer, if present.

3. **Forest Strip Width (ft.):** This is the width of the forest buffer (not including the grass strip).

4. **Fraction of field treated by buffer:** This is the estimated fraction (0.00-1.00) of the runoff from the field that is routed through the buffer.

5. **Is buffer included in AOI?:** If buffer has been drawn as part of the AOI, then the area will be subtracted from the crop area. If it has not been drawn as part of the AOI, it will be assumed to be adjacent to one edge of the field.

Grass buffers, also known as a filter strips, are an area of vegetation, generally narrow in width and long across the downslope edge of a field, that slows the rate of runoff, allowing sediments, organic matter, and other pollutants that are being conveyed by the water to be removed by settling out. Filter strips reduce erosion and the accompanying sediment-bound pollution.

In NTT, filter strips function by providing for better infiltration of soluble nutrients, trapping of sediment, and increased uptake of water and nutrients by the filter strip vegetation. The saturated conductivity value is also modified for filter strip simulation in NTT.

The inputs for grass buffers are the same as for forest buffers (see Forest Buffer), with the additional requirement that the user specify type of vegetation.

Vegetation: This is the type of grass or vegetation that is planted in the Filter Strip.

Grass Waterway

A grassed waterway is a natural or constructed swale, shaped or graded and established in suitable vegetation for the safe conveyance of runoff. Grassed waterways are designed to prevent soil erosion while draining runoff water from adjacent cropland. As water travels down the waterway, the grass vegetation prevents erosion that would otherwise result from concentrated flows and uptakes nutrients. Grassed waterways also help prevent gully erosion in areas of concentrated flow. For example, they may be used to drain runoff from terraces and runoff water diversions. By intercepting runoff, grassed waterways slow erosion and minimize nutrient losses. The inputs for Waterways include:

1. **Crop:** This is the type of grass or vegetation that is used in the channel.

2. **Width:** This is the width of the grassed waterway, in feet, including both sides of the vegetated channel. This can be any number greater than 0.

3. **Fraction of field treated by grass waterway:** The fraction of the field that drains to the grass waterway. A number between 0.00 and 1.00.

Contour Buffer (Strip Farming)

Contour buffer strips are permanent, narrow bands of grasses/legumes planted on the contour (across or perpendicular to a slope) between wider strips of crops. Contour buffers trap sediment and enhance filtration of nutrients and pesticides by slowing down runoff that could enter the local surface waters. User input fields for contour buffers include:

1. **Crop:** This is the type of grass or vegetation that will be present in the buffer sections of the contour buffer.

2. **Grass buffer Width:** This is the width, in feet, of the buffer strips. It can be any number greater than 0. Buffer width, along with crop width, determine the number of buffer and crop strips in the field.

3. **Crop strip Width:** This is the width, in feet, of the strips of the main crop that was planted. It can be any number greater than 0. Crop width, along with buffer width, determine the number of buffer and crop strips in the field.

Land Leveling

Land leveling is used to reduce the slope on high soil slopes. By reducing the slope, the surface land is better able to retain water and soil, reducing erosion and increasing infiltration. The input for land leveling is slope reduction percentage.

1. **Slope Reduction:** This is the percent reduction in the slope of the soil. The number can be any percentage between 0% and 100%. The closer the slope is to 100, the more the slope is reduced.

Terrace System

A terrace system is a leveled section of a hill cultivated area, designed as a method of soil conservation to slow or prevent the rapid surface runoff of water. Terraces decrease hill slopelength, reduce formation of gullies, and intercept and conduct runoff to a safe outlet thereby reducing sediment content in runoff water. Often, in application the landscape is formed into multiple terraces, giving a stepped appearance. Terraces are simulated by reducing the practice factor (PEC). If you would like to apply a terrace system, click on the **Select** button.

Reference

* See USDA
website: http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/technical/?&cid=nrcs143_026849 for more detailed term descriptions.

Results Page

The results page allows you to view the results for the field/scenario combinations that you simulated. You cannot review the results unless the field/scenario has been simulated. Please see simulating scenarios for more information.

Viewing the Results

To view the results on one or more field scenarios, the user may click the **View Results** button at the top of the Scenario Management page. Alternately, the user may click on **Results** in the left navigation menu.

After clicking on View Results, the user will be directed to the Tabluar View page as a default. Users may also choose to view data in graphical view by clicking Annual-Chart or Monthly-Chart on the side navigation menu.

Tabular View

To compare the results of up to three field scenarios in the tabular view, use the drop down to select each field scenario. Click View when you are finished.

HINT: if you only have one or two scenarios you wish to compare, select the same scenario multiple times so that there is a scenario selected for each column of the tabular display.

The user may toggle between two different units in the tabular view. The user may view results in units/acre (e.g., lbs/acre) or as total units summed across the area of the field (e.g., lbs).

After clicking View, the table will populate with the results of each scenario. Users have the option of downloading the results as a CSV file, or as a PDF file.

Interpreting Tabular Results

The scenario results presented in your table represent AVERAGE annual edge of field losses across the period of simulation. NTT simulates over a period of 35 years. To view year by year results, the user can view use the Graphical results feature (See View Graphical Results.). The name of Scenario 1 will appear at the top of the first Losses column. This column displays the nutrient, sediment and flow losses at the edge of the field for Scenario 1 in addition to the estimated yields. Scenario 1 is the first column of data, Scenario 2 results are represented in the next column and highlighted in a different color. In addition to displaying results in the "Losses" column, Scenario 2 also has a "Change" column that represents the change in losses between scenario 1 and scenario 2. Scenario 3 results are also highlighted in another color. The Change column represents the change in losses between scenario 1 and scenario 3.

NTT is designed to compare a baseline scenario (present) with an alternative scenario (future). Because of this, it is assumed that the user will be looking for improvements in the alternative scenario. This means that **negative numbers in the difference and reduction % represent an**

undesirable result (e.g. increased losses as compared to scenario 1) and positive numbers indicate a desired result (e.g. reduced losses as compared to scenario 1).

Expanding Results

In the Tabular view, results for Total Nitrogen, Total Phosphorus, surface/subsurface & Tile Drain flow, Other Water info, Total sediment, and yield are summarized. To drill-down, click the check box next to the row of interest. For instance, when expanding the Total Nitrogen row, users will be able to view the results for Organic N, Runoff N, Subsurface N and Tile Drain N, which comprise the Total Nitrogen losses value.

Viewing Results Graphically

In addition to being able to view your results in tabular form, NTT also provides the option of viewing results graphically. There are two graphical views for the user to select from: annual and monthly results. The user can select these views using the left navigation menu. **Annual Charts (most recent 12 Years):** Annual charts allow users to view the annual average losses for a specific constituents (for example flow or sediment) for the most recent 12 years of the simulation. To select the annual view, click Annual-Chart in the left navigation menu. Once this option has been selected, the user selects the scenarios they would like to compare, and the constituent they would like to view, as shown below. This will bring up the selected results on the graph. In addition to the graph, the annual results are displayed below the graph in tabular form and can also be exported.

1. **Monthly Chart (The entire period):** The monthly chart view allows users to view monthly average losses for particular constituents over the period of the simulation (35 years). To view the monthly chart view, click Monthly-Chart from the left hand navigation menu. Monthly charts are limited to constituents that APEX summarizes monthly (see drop-down list of options below).
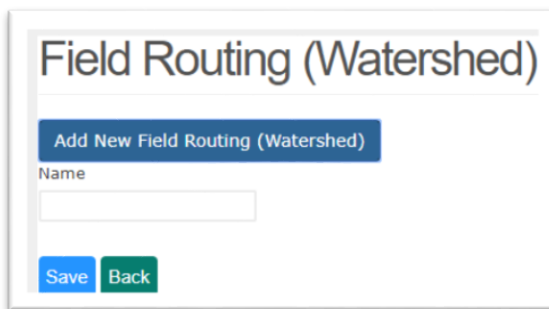
Field Routing (Watershed) Scenarios

The field routing/watershed feature allows users to simulate routing between fields. Alternately, users can use the field routing function to simulate a watershed, where instead of fields, the AOIs represent subbasins. A routing scenario will route runoff, sediment, and nutrients from one field to the next (or from one subbasin to the next if used to simulate a watershed) in the specified order. For each routing scenario/watershed created by the user, the user will need to list the field-scenario routing order. When viewing your results, you may note that the load at the outlet of the watershed is less than the sum of the edge of field loads for each individually simulated field/subbasin. This is because NTT simulates attenuation effects of water and nutrients as they flow over the landscape.

Create/Name Your Watershed

To begin creating a field routing scenario, click Add New Field Routing (Watershed). Once you do this, a text box will pop up where you can type in the name of the scenario:

Once you enter the name, click **Save**.

Build Watershed Scenario

Once you have created and named your field routing/watershed scenario, it will appear in the list of watershed scenarios. Click the watershed scenario **name** to begin defining your watershed scenario.

When building your watershed scenario, you will begin adding fields/scenarios in the order that you wish to route the flow between fields. You may not add a field more than once to the same watershed scenario (the idea is combining fields to simulate as one field). To add field/scenario combinations to the watershed scenario, select the field and scenario from the drop down lists and click **Add Fields / Scenario**. Continue to add fields/scenarios until your watershed scenario is complete.

Once you have finished selecting, click **Back** to go back to the watershed page.

Manage Watershed Scenarios

The list of watershed scenarios that you have created will appear on the Field Routing (Watershed) page.

To begin defining your watershed scenario, or to edit a watershed scenario that you have already defined, click on the scenario **name** to begin defining/editing the scenario.

To delete your watershed scenario, click the delete ✖ icon.

To rename your watershed scenario, click the edit ✎ icon.

Simulating/Viewing Results for Field Routing

To simulate a watershed scenario, select the name(s) of the watershed to stimulate and click **Stimulate Selected Field Routing (Watershed)**. Your watershed may take a few minutes to simulate. Once simulation is complete, a simulation date/time will appear in the Simulation Date field next to the watershed scenario name.

To view results for field routings, select the scenario(s) you wish to view and click View **Results**. Results of Field Routing/Watershed scenarios are displayed in the same way that results are displayed for individual fields—with both tabular and graphical views.